



## Percolation from Agricultural Lands

This EnviroAtlas national map provides modeled estimates of percolation (vertical) flow from the bottom of the soil layer underlying agricultural fields within each 12-digit hydrologic unit (HUC) in millimeters (mm) of water for 2002. It does not necessarily reflect the amount of water that actually enters an underlying groundwater reservoir. Percolation is the downward movement of water within soil. The rate of percolation is affected by soil characteristics, with water moving through coarser soils more quickly than through fine-grained soils.

### Why is percolation from agricultural lands important?

Agriculture can affect the quantity and quality of water in streams and waterbodies. Percolation can contribute to groundwater recharge (the process of water entering an aquifer) and stream baseflows (the steady flow of water into streams between storms). Percolation from fields can also carry pollutants to streams and groundwater and change the hydrology of watersheds. Water percolates through the unsaturated zone, a soil zone close to the surface. Eventually some of this water may reach the water table, where the ground is saturated with water to form groundwater aquifers.

In many areas, groundwater pumping for irrigation has led to aquifers being depleted faster than they can be recharged.<sup>1</sup> Percolation from agricultural fields can contribute to aquifer recharge.<sup>1,2</sup> However, only some of the water applied to fields through irrigation or precipitation percolates into the soil, and in most places a large percentage of that water evaporates or is transpired by plants before it reaches the water table.<sup>1</sup> Percolation rates are affected by land use and soil texture. Coarser soils allow more percolation than fine soils.

Nutrients and other pollutants can be carried in water percolating through the soil.<sup>2</sup> Some pesticides can be transferred to groundwater; this can affect the health of groundwater species (e.g., worms, snails, and insects) and contaminate wells.<sup>3</sup> Well water contaminated with high levels of nitrate, a nitrogen compound that can be introduced by fertilizer, can cause an illness in infants called methemoglobinemia or [blue-baby syndrome](#).

### How can I use this information?

The map, Percolation from agricultural lands, can be used to identify potential sources of water pollution and to understand



hydrologic changes associated with agriculture. They can be viewed with layers describing water demand to suggest how percolation might affect the water supply. While the model output is based on 2001/2001 data that may not represent current conditions, the information about the movement of water at the edge of agricultural fields can be used as a baseline to compare with current and future projections.

### How was the data for this map created?

These data were created using the [Fertilizer Emissions Scenario Tool for CMAQ \(FEST-C\)](#). FEST-C combines Meteorology data for 2002 produced by the [Weather Research Forecast model](#) v3.4 and wet and dry atmospheric deposition to agricultural soils estimated by bidirectional CMAQ5.2<sup>4</sup> with field-level biogeochemistry and edge-of-field water movement simulated by the [Environmental Policy Integrated Climate \(EPIC\) model](#). Simulations were performed for more than 100,000 rectangular grid cells (12km on a side) that form a continuous modeling layer across the conterminous U.S. These EPIC simulations are representative of regional, rather than local-scale conditions and assume conservation tillage on representative soils for specific crops at the HUC-8 (subbasin) scale. Irrigated and rain fed management simulations were performed for each of 22 major commercial crops. The results were then aggregated across all agricultural land in a simulation grid cell.<sup>5</sup> In order to pair land use with the meteorological and emission scenarios, the agricultural area in each grid cell was estimated using National Land Cover Database (NLCD) 2001 and US Department of Agriculture (USDA) 2002 Census of Agriculture county-level data. The gridded data are summarized by 12-digit HUC. For detailed information on how this data was generated, see the [metadata](#).

## What are the limitations of these data?

EnviroAtlas uses the best data available, but there are still limitations associated with these data. These data layers contain substantial uncertainties; they are based on models and large national geospatial databases. This map reflects assumptions about soil, weather, crop variety, and crop-specific management conditions in each 12-digit hydrologic unit. Given that 2001/2002 deposition, land use, and management practices data were used in the modeling effort, the data layer may not be representative of current conditions. Early simulation design and performance evaluation for 2002 yield, fertilizer use and predicted plant and harvest dates are reported in Cooter et al.<sup>5</sup> These simulations represent nutrient applications that roughly follow regional nutrient management practices on the most prevalent agricultural soils as identified in the [National Resources Inventory](#) at the HUC-8 level. The use of average grid cell slope could result in the over-estimation of horizontal water and nutrient losses by the model for some crop/soil combinations, particularly for tile drainage systems. Regional-scale studies of edge-of-field N and P losses are not generally available. Comparison of some of these 2002 EPIC nutrient export results for the Upper Mississippi River Basin (UMRB), which lies within the larger Mississippi/Atchafalaya River Basin, to other published modeling studies are presented in Cooter et al.<sup>6</sup> Further comparison of model estimates of crop yield, fertilizer

application amounts and timing, crop planting and harvest dates, and irrigation water use agree with [USDA](#) and US Geological Survey ([USGS](#)) estimates that rely heavily on site-specific survey information representing long-term average conditions in terms of overall spatial pattern and magnitude.<sup>7,8</sup>

## How can I access these data?

EnviroAtlas data can be viewed in the interactive map, accessed through web services, or downloaded. The NLCD 2001 can be downloaded from the [MRLC](#) and the Census of Agriculture can be downloaded from the USDA's [website](#).

## Where can I get more information?

A selection of publications related to subsurface flow and dissolved nutrients is listed below. To ask specific questions about this data layer, please contact the [EnviroAtlas Team](#).

## Acknowledgments

The data for this map were generated by Ellen Cooter (FEST-C) and Jesse Bash (CMAQ), Computational Exposure Division, US EPA; Limei Ran, Dongmei Yang, UNC Institute of the Environment; and Verel Benson, Benson Consulting (FEST-C). Ellen Cooter, Computational Exposure Division (CED), Atmospheric Model Analysis and Application Branch, US EPA, and Megan Culler, EPA Student Services Contractor created this fact sheet.

## Selected Publications

1. Alley, W.M. 2002. [Flow and storage in groundwater systems](#). *Science* 296:1985–1990.
2. Scanlon, B.R., R.C. Reedy, J.B. Gates, and P.H. Gowda. 2010. [Impact of agroecosystems on groundwater resources in the Central High Plains, USA](#). *Agriculture, Ecosystems & Environment* 139:700–713.
3. Marmonier, P., C. Maazouzi, N. Baran, S. Blanchet, A. Ritter, M. Saplaïroles, M.-J. Dole-Olivier, D.M.P. Galassi, D. Eme, S. Dolédec, and C. Piscart. 2018. [Ecology-based evaluation of groundwater ecosystems under intensive agriculture: A combination of community analysis and sentinel exposure](#). *Science of The Total Environment* 613–614:1353–1366
4. Appel, K.W., K.M. Foley, J.O. Bash, R.W. Pinder, R.L. Dennis, D.J. Allen, and K. Pickering. 2011. [A multi-resolution assessment of the Community Multiscale Air Quality \(CMAQ\) model v4.7 wet deposition estimates for 2002–2006](#). *Geoscientific Model Development* 4:357–371.
5. Cooter, E., J. Bash, V. Benson, and L. Ran. 2012. [Linking agricultural crop management and air quality models for regional to national-scale nitrogen assessments](#). *Biogeosciences* 9:4023–4035.
6. Cooter, E.J., L. Ran, D. Yuan, and V. Benson. 2017. [Exploring a United States maize cellulose biofuel scenario using an integrated energy and agricultural markets solution approach](#). *Annals of Agricultural and Crop Sciences* 2(2):1031.
7. Brakebill, J.W., and J.M. Gronberg. 2017. [County-level estimates of nitrogen and phosphorus from commercial fertilizer for the conterminous United States, 1987–2012](#): U.S. Geological Survey data release.
8. Yuan, Y., R. Wang, E. Cooter, L. Ran, P. Daggupati, D. Yang, R. Srinivasan, and A. Jalowska. 2018. [Integrating multimedia models to assess nitrogen losses from the Mississippi basin to the Gulf of Mexico](#). *Biogeosciences* 15:7059–7076.